The present application constitutes a continuation-in-part of my copending U.S. patent application, Ser. No. 246,490, filed Dec. 21, 1962, now abandoned.

This invention relates in general to protective armor coating, or plating, and more particularly to such an armor coating or plating directed toward preventing a projectile or a particle therefrom from traversing therethrough.

Whether a projectile enters conventional armor plating at an angle or directly perpendicular to the plating surface generally does not operate to change the effectiveness of the plating other than to require the projectile entering at an angle to traverse a greater distance of plate. Thus, thickness alone has been the primary measure of the efficiency of armor plates of a particular material.

Recent improvements in armor plating, however, have taken the direction of providing a tipping plate in addition to the armor plate whereby particles or projectiles entering armor plating at an angle more than 15° from the normal are diverted from their course by a first plate and are caused to strike the heavier inner plating at a greatly increased angle and in fact perhaps broadside, thereby rendering the inner plating much more effective in stopping the projectile. Such increased effectiveness results from energy transfer as well as a greater area contacted by the turned projectile. Another attempt at improvement, the use of sharply angled V-sections joined in the form of a corrugated metallic liner mounted against a plate, has generally not been successful in adding to the effectiveness of protection per amount of metal utilized because of the large percentage of area which is ineffective.

Such attempts to increase the protection afforded by armor plate have serious disadvantages of either extreme weight for dense-mass stopping or repelling a projectile, or use of excessive space around the object to be protected such as required by the tipping plate which is spaced a minimum of 12 inches beyond the heavy inner plating and which thereafter results in a bulky protective shield. Both of these types of armor plating usually require the use of metal and are therefore further subject to limited or restricted use at times when metal is scarce.

The present invention avoids the disadvantages of the foregoing types of armor plating for protecting against projectiles by providing an improved lightweight armor plate of considerably less bulkiness than conventional metallic armor plate and which may be composed of all non-metallic materials or a composite of metallic and non-metallic materials.

Accordingly, it is an object of the present invention to provide a protective composite armor plate capable of stopping or diverting projectiles of various sizes and composed primarily of non-metallic materials. It is another object of the present invention to provide a composite armor plate capable of stopping or diverting projectiles which occupies substantially the same volume and has substantially less weight than prior armor platings or plate systems of comparable effectiveness.

It is another object of the present invention to provide an improved lightweight armor plate comprising a plurality of energy-dissipating elements embedded in a non-metallic body in spaced apart relationship, wherein a minimum number of the energy-dissipating elements are adapted to be shattered when subjected to the impact of a projectile thereagainst while causing fragmentation of the projectile to effectively dissipate its energy so as to stop or divert the projectile.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIGURE 1 is an isometric view in section of one embodiment of the invention;

FIGURE 2 is an isometric view in section of another embodiment of the invention;

FIGURE 3a is an isometric view in section, and partially broken away, of another embodiment of the invention;

FIGURE 3b is an isometric view in section similar to FIGURE 3a, but showing another embodiment of the invention;

FIGURE 4 is an enlarged isometric view of an alternate component for the embodiments illustrated in FIGURES 3a and 3b;

FIGURE 5a is a sectional view showing a conventional type of metallic armor plate and the manner in which a projectile is stopped thereby;

FIGURE 5b is a sectional view showing another conventional type of metallic armor plating and the manner in which a projectile is stopped thereby; and

FIGURE 5c is a sectional view showing a lightweight armor plate in accordance with the present invention and showing the manner in which a projectile is stopped thereby.

Referring more specifically to the drawings, the embodiments of the present invention are directed generally toward a lightweight composite armor plate providing protection against flying particles or projectiles. The armor plate is adapted to be mounted about an area requiring protection and is so constructed that a projectile, regardless of the angle at which the projectile strikes the armor plate, is diverted from its course in a manner in which the force of the projectile is dissipated through the shattering of a component of the armor plate struck by the projectile causing the projectile itself to be broken into fragments, whereby the integrity of the protected area is maintained. The armor plate comprises a plurality of such components, hereinafter termed energy-dissipating elements, and a solid mass of a suitable high strength reinforced plastic forming the body of the armor plate in which the energy-dissipating elements are embedded in spaced relation to each other. Preferably, the energy-dissipating elements are made of hard ceramic material, such as aluminum oxide, nickel-plated aluminum oxide, or boron carbide, although the energy-dissipating elements may be made of a suitable metal or other material suitable for dissipating the force of a projectile by shattering upon impact of the projectile thereagainst.

In FIGURE 1, the composite lightweight armor plate 11 therein shown comprises a plurality of energy-dissipating elements in the form of spheres or balls 12 which are embedded in the plastic body 16 of the armor plate 11 in spaced relation to each other. The spheres 12 are arranged in plural interrupted layers or courses in the body 16 of the armor plate 11, two such layers of spheres 12 being shown, the spheres 12 being spaced apart and the spheres 12 in one layer being staggered with respect to corresponding spheres 12 in the other layer. The plastic body 16 of the armor plate 11 has a considerably heavier or thicker portion disposed on the side of the spheres 12 adjacent to the area to be protected by the armor plate.
The spheres 12 may be positioned and secured in the plastic body 16 of the armor plate 11 adjacent to layers 14 which may be of metal substrate or strong fabric. The layers 14 form front and rear boundaries for the spheres 12 so as to generally confine any particles from the spheres 12 or the projectile 15 upon impact of the projectile 15 against the composite armor plate 11 to the area between the layers 14. In FIGURE 1 the projectile 15 is shown at the moment of entry into the armor plate 11 in a heading normal to the armor plate 11 in phantom lines, and after entry in full lines to indicate the curved path traversed by the projectile 15 within the armor plate 11, thereby showing the effect of the armor plate 11 in causing diversion of the projectile from its original course and fragmentation of the projectile. By such diversion and fragmentation of the projectile, a substantial amount of the energy of the projectile is expended, and the projectile is stopped by the armor plate 11.

Therefore, with the present arrangement, the projectile 15 upon entering the armor plate 11 and striking a sphere 12 causes the sphere 12 to shatter, while being broken into fragments, to substantially dissipate the force of the projectile 15—the path of the projectile 15 also being diverted with the fragmentation of the projectile 15—so that the fragments of the projectile 15 continue on a diverging course and either will be contained in the armor plate 11 or will have an exceedingly high amount of energy expended therein so that the projectile 15 is rendered ineffective. It should be understood that varying the thicknesses of the plastic body 16 and sizes of spheres 12 may be employed in the composite armor plate 11 in relation to the size and weight of the projectile against which protection is desired.

As noted, two layers of spheres 12 are shown in FIGURE 1 such that a typical projectile having a pointed tip or nose will enter the plastic body 16 of the armor plate 11 at a position substantially equidistant from two or more spheres 12 in one layer of spheres 12 will nevertheless strike a sphere 12 in the other layer to shatter the impacted sphere 12, thereby diverting the projectile and breaking it into fragments for expending its energy to stop the projectile.

In the embodiment of the invention illustrated in FIGURE 2, the energy-dissipating elements take the form of elongated cylinders 20 having circular transverse cross-sections. The cylinders 20 effect diversion and fragmentation as do the spheres 12 of FIGURE 1. These cylinders 20 are embedded in the plastic body 16 so as to be arranged in plural interrupted layers or courses, two such layers of cylinders 20 being shown, the cylinders 20 being spaced apart and the cylinders 20 in one layer being staggered with respect to corresponding cylinders 20 in the other layer. Undulating layers of spacing material 17 may also be embedded in the plastic body 16, each layer of spacing material 17 being alternately wound over and under the cylinders 20 in a respective layer thereof. The spacing material 17 is preferably made of reinforced, plastic-impregnated, woven fabric in sheet form and aids in restricting or limiting the shattering of the cylinders 20 to the immediate region where the projectile enters the armor plate 11 of FIGURE 2. In this respect, the layers of spacing material 17 substantially reduce or prevent the transfer of stress waves from the projectile 15, which would otherwise have a tendency to cause shattering of the cylinders 20 over a large area from the impact of a single projectile to reduce the effectiveness of the armor plate.

It will be understood that the cylinders 20 which have circular cross-sections may be replaced by elongated energy-dissipating elements having various cross-sectional shapes, other than circular, which require less material than the cylinders 20 to further reduce the weight and cost of the armor plate 11 shown in FIGURE 2.

Another embodiment of the invention is shown in FIGURE 3a wherein the energy-dissipating elements embedded in the plastic body 16 of the armor plate 11 are substantially square plate members or tiles 30 having planar or flat front and rear surfaces. The tiles 30 are arranged in spaced relationship with respect to each other in a single interrupted layer or course as shown, although FIGURE 3c may include interrupted layers or courses of the tiles 30 to increase the protection afforded thereby—the increased protection being accompanied, however, by a corresponding increase in the bulk of the armor plate.

In the embodiment illustrated in FIGURE 3a, the composite armor plate 11 includes a metallic backing plate 31 bonded or otherwise suitably secured to the rear surface of the plastic body 16. The metallic backing plate 31 is preferably made of a lightweight metal of high strength, such as aluminum or titanium, and serves as added protection by diverting or stopping fragments of the projectile 15 after the projectile 15 has entered the armor plate 11 and has shatted one of the tiles 30 to become broken into fragments and diverted from its original path. It will be understood that a metallic backing plate similar to the metallic backing plate 31 shown in FIGURE 3a may also be included as a component of the embodiments of the composite armor plate illustrated in FIGURES 1 and 2.

FIGURE 3b shows another modification of the composite armor plate 11 which is generally similar to the embodiment illustrated in FIGURE 3a. The modified composite armor plate 11 of FIGURE 3b includes layers 33 and 34 of woven material respectively disposed over the front and back surfaces of the tiles 30. The layers 33 and 34 of woven material are made of a suitable reinforced, plastic-impregnated fabric, such as “Darcon” or “Nomex” fiber glass. The layers 33 and 34 of woven material comprise anti-spalling means to prevent fragments from the tiles 30 which are shattered upon being struck by a projectile from being rapidly expelled away from the composite armor plate 11. This is an added safety feature to protect personnel and equipment in the area shielded by the composite armor plate 11 from injury or damage which could result from flying fragments of the tiles 30 when they are shattered. The plastic matrix bonding the tiles 30 together in substantially conforming, but spaced relationship, comprises the plastic body 16 in which the tiles 30 are embodied.

In the modified composite armor plate 11 of FIGURE 3b, an elastomeric liner or sheet 35 is sandwiched between the matrix comprising the plastic body 16 and the metallic backing plate 31 with the anti-spalling layer 34 of woven material being disposed between the tiles 30 and the liner 35. The elastomeric liner 35 in addition to providing structural support for the composite armor plate 11 also serves to further absorb the impact energy of a projectile striking the composite armor plate 11 and/or to transmit such impact energy to the metallic backing plate 31 without causing the shattering of tiles 30 adjacent to the tile 30 which is directly impacted by the projectile and shattered. The liner 35 may be made of any elastomeric material suitable for the purpose desired, one such suitable elastomeric material being a nitrile rubber indentified as Gen-Gard V-45 manufactured by the General Tire and Rubber Company of Akron, Ohio.

It may be generally stated that a single layer of the energy-dissipating elements embedded in the plastic body 16 in each of the embodiments shown in FIGURES 1, 2, 3a and 3b will be less effective in diverting a projectile 15 entering the armor plate 11 through the front surface thereof than would two or more layers of the energy-dissipating elements. However, it has been determined that where a projectile enters the armor plate at a minimum deviation of 15° from a perpendicular relationship to the front surface thereof, a single layer of energy-
dissipating elements embedded in the plastic body of the armor plate is substantially as effective in stopping the projectile layers. Although the plate members or tiles 30 in FIGURES 3a and 3b are shown as having a substantially square shape, it is within the spirit of this invention to form tiles having planar or flat front and rear surfaces in a wide variety of shapes including various polygonal shapes, for example, for use as the energy-dissipating elements of the armor plate shown in FIGURES 3c and 3d. One such alternate shape is the pentagonal tile 32 of FIGURE 4.

To better understand the action of the composite armor plate in accordance with the present invention in stopping a projectile as compared to conventional armor plate structures, reference is made to FIGURES 5a, 5b, and 5c. FIGURE 5a illustrates the entrance of a projectile into a conventional metallic armor plate where stopping of the projectile is predicated primarily on the thickness of the metallic armor plate. FIGURE 5b illustrates another form of conventional metallic armor plating which includes a metallic tipping plate and a metallic armor plate of increased thickness relative to the metallic tipping plate and spaced to the rear thereof, wherein a projectile entering the composite metallic armor plating at an angle deviating by at least 15° from perpendicular to the front surface thereof is diverted by the metallic tipping plate so that the projectile will be caused to strike the heavier armor plate at a greatly increased angle of deviation from perpendicular relation thereto to increase the effectiveness of the heavier armor plate in stopping the projectile. FIGURE 5c illustrates the action of the energy-dissipating elements in the composite lightweight armor plate according to the present invention in diverting a projectile and breaking it into fragments.

In accordance with the invention, the energy-dissipating elements of the composite armor plate are made of a material providing a very hard and rigid surface for the energy-dissipating elements to be resistant to penetration of the entering point of the projectile. The energy-dissipating elements are embedded in the plastic body of the composite armor plate such that they are substantially rigidly held in place so that they cannot be swept aside by the projectile on its passage through the composite armor plate.

Although it is intended that an energy-dissipating element will be shattered upon impact of a projectile thereagainst, it is desirable to dissipate substantial energy from the projectile, the material of the energy-dissipating elements is not readily crushable, because the energy-dissipating elements must be capable of breaking the projectile into fragments and diverting the fragmented projectile from its original path. It has been determined that a minimum hardness of the order of 400 Knoop is required for the material of the energy-dissipating elements to obtain satisfactory protection from the composite armor plate. The unit of measure Knoop refers to the Knoop value of hardness for a 500 gram load. In the latter respect, the Knoop value of hardness is obtained from a hardness test which relies upon the indentation of a diamond pyramid whose dimensions are known into a polished specimen of material whose hardness is to be measured, where the indenting load in grams of the diamond pyramid imposed on the specimen is expressed in the Knoop value as a subscript. Nickel-plated aluminum oxide which is one of the preferred ceramic materials suitable for the energy-dissipating elements has a Knoop hardness value in excess of 1200 Knoop.

As noted, the body of the composite armor plate in the embodiments thereof illustrated in FIGURES 1, 2, 3a, and 3b may be a suitable high strength reinforced plastic material, such as for example a thermo-setting epoxy resin reinforced by fiber glass of the type disclosed in my copending U.S. patent application, Ser. No. 241,569, filed Dec. 3, 1962, now abandoned. Since the plastic body of the composite armor plate as constructed in accordance with the present invention must serve as an effective carrier for the energy-dissipating elements embedded therein, it should exhibit a high resistance to shattering when subjected to the impact of a projectile such that the plastic body of the composite armor plate will remain substantially intact while one or more of the energy-dissipating elements embedded therein are shattered upon being struck by the projectile to absorb a substantial amount of its energy and cause it to break into fragments.

As illustrated, the forwardly and rearwardly disposed layers of energy-dissipating elements in the forms of the composite armor plate of FIGURES 1 and 2, and the forwardly and rearwardly facing surfaces of the layer of energy-dissipating elements of the composite armor plate of FIGURE 3 are preferably covered by respective layers of the same high strength reinforced plastic material which forms the body of the composite armor plate. These layers of plastic material may be an integral part of the plastic body 16 (as in FIGURE 3e) or may be formed as discrete layers (as in FIGURE 2) suitably laminated to the plastic body 16 to provide a unitary construction. In the armor plate of FIGURE 1, these layers of plastic material may be either an integral part of the plastic body 16 or discrete layers laminated to the layers 14, depending upon the nature of the layers 14 which may be metal or woven fabric, for example. These outer layers of plastic material effectively serve as anti-spalling means to prevent particles from the energy-dissipating elements which are shattered and being struck by a projectile from flying outwardly from the front and rear surfaces of the composite armor plate.

By the present invention, a composite relatively thin armor plate of primarily non-metallic materials is provided for effectively stopping a projectile, wherein the composite armor plate may have a thickness equal to or less than that of conventional armor plating of comparable effectiveness while being of substantially reduced weight as compared thereto.

I claim:
1. A lightweight armor plate for protecting an area against high energy particles, such as projectiles, by resisting the penetration thereof, said armor plate comprising
(a) a body of non-metallic, shatter-resistant material,
(b) a plurality of spherical fragmentation-inducing and energy-dissipating elements embedded in said non-metallic body so as to resists said particles thereby, said spherical fragmentation-inducing and energy-dissipating elements being arranged in at least one layer and in spaced relationship with respect to each other in said body,
(c) said plurality of spherical fragmentation-inducing and energy-dissipating elements being individually shatterable in response to the impact of a high energy particle thereagainst to cause the high energy particle to be broken into fragments for dissipating the force of the high energy particle while tending to divert the path taken by the fragments of the high energy particle,
(d) layers of anti-spalling material in said body and respectively disposed forwardly and rearwardly of said spherical fragmentation-inducing and energy-dissipating elements to define confining boundaries therefor, and
(e) said spherical fragmentation-inducing and energy-dissipating elements, said layers of anti-spalling material, and said non-metallic body cooperating to define a composite plate-like structure capable of containing the fragments of the high energy particle and fragments from said spherical fragmentation-inducing and energy-dissipating elements therewithin, wherein said layers of anti-spalling material in said
body prevent the shattered portions of an individual spherical fragmentation-inducing and energy-dissipating element struck by a high energy particle from flying outwardly away from the composite plate-like structure.

2. A lightweight armor plate for protecting an area against high energy particles, such as projectiles, by resisting the penetration thereof, said armor plate comprising
(a) a body of non-metallic, shatter-resistant material,
(b) a plurality of elongated cylindrical fragmentation-inducing and energy-dissipating elements embedded in said non-metallic body so as to be rigidly held in place thereby, said cylindrical fragmentation-inducing and energy-dissipating elements being arranged in plural layers and in spaced parallel relationship with respect to each other in said body,
(c) the cylindrical fragmentation-inducing and energy-dissipating elements in one layer being disposed in staggered relation with respect to respective corresponding cylindrical fragmentation-inducing and energy-dissipating elements in an adjacent layer,
(d) said plurality of cylindrical fragmentation-inducing and energy-dissipating elements being individually shatterable in response to the impact of a high energy particle thereagainst to cause the high energy particle to be broken into fragments for dissipating the force of the high energy particle while tending to divert the path taken by the fragments of the high energy particle,
(e) undulating layers of anti-spalling material in said body and being disposed alternately over and under the cylindrical fragmentation-inducing and energy-dissipating elements in respective layers thereof, and
(f) said cylindrical fragmentation-inducing and energy-dissipating elements, said undulating layers of anti-spalling material, and said non-metallic body cooperating to define a composite plate-like structure capable of containing the fragments of the high energy particle and fragments from said cylindrical fragmentation-inducing and energy-dissipating elements therewithin, wherein said undulating layers of anti-spalling material restrict shattering of an individual cylindrical fragmentation-inducing and energy-dissipating element struck by a high energy particle to the immediate region where the high energy particle enters the composite plate-like structure.

3. A lightweight armor plate for protecting an area against high energy particles, such as projectiles, by resisting the penetration thereof, said armor plate comprising
(a) a plurality of ceramic tiles of a selected predetermined size and shape having substantially planar front and rear faces, said ceramic tiles being arranged in at least one layer and in closely spaced relationship with respect to each other,
(b) a shatter-resistant plastic material bonding said plurality of ceramic tiles together so as to rigidly hold said ceramic tiles in place,
(c) anti-spalling front and rear fabric webs respectively secured to the front and rear faces of said plurality of ceramic tiles in covering relation thereto,
(d) an elastomeric liner disposed across the rear fabric web covering the rear faces of said plurality of ceramic tiles and secured to said rear fabric web,
(e) a metallic back-up plate secured to said elastomeric liner in covering relation thereto,
(f) said plurality of ceramic tiles being individually shatterable in response to the impact of a high energy particle thereagainst to cause the high energy particle to be broken into fragments for dissipating the force of the high energy particle while tending to divert the path taken by the fragments of the high energy particle, and
(g) said ceramic tiles, said shatter-resistant plastic

material, said anti-spalling front and rear webs, said elastomeric liner, and said metallic back-up plate cooperating to define a composite plate-like structure capable of containing the fragments of the high energy particle and fragments from said ceramic tiles therewithin, wherein said anti-spalling front and rear webs serve to prevent the shattered portions of an individual ceramic tile struck by a high energy particle from flying outwardly away from the composite plate-like structure.

4. A lightweight armor plate as defined in claim 3, wherein
(a) each of said ceramic tiles has a substantially square shape.

5. A lightweight armor plate as defined in claim 3, wherein
(a) each of said ceramic tiles has a shape in the form of a polygon having more than four sides.

6. A lightweight armor plate as defined in claim 3, wherein
(a) each of said ceramic tiles has a hardness value of at least 400 Knoop, and
(b) said shatter-resistant plastic material comprises a thermo-setting resin reinforced by glass fibers.

7. A lightweight armor plate as defined in claim 3, wherein
(a) each of said ceramic tiles has a hardness value in excess of 1200 Knoop, and
(b) said shatter-resistant plastic material comprises a thermo-setting resin reinforced by glass fibers.

8. A lightweight armor plate for protecting an area against high energy particles, such as projectiles, by resisting the penetration thereof, said armor plate comprising
(a) a fragmentation-inducing and energy-dissipating ceramic plate member provided with forward and rear surfaces having a significant area, said forward surface of said ceramic plate member being disposed in a direction opposed to the probable path to be taken by a high energy particle,
(b) said ceramic plate member being made of a material having a hardness value in excess of 1200 Knoop,
(c) back-up layer means of shatter-resistant material supporting said ceramic plate member and disposed adjacent the rear surface thereof in covering relation to the entire area of said rear surface,
(d) said ceramic plate member being shatterable in response to the impact of a high energy particle striking the forward surface thereof to cause the high energy particle to be broken into fragments for dissipating the force of the high energy particle while tending to divert the path taken by the fragments of the high energy particle, and
(e) said back-up layer means being of sufficient toughness and strength so as to contain the fragments of the high energy particle and fragments from said ceramic plate member therewithin, thereby preventing the passage of such fragments through said back-up layer means.

9. A lightweight armor plate as defined in claim 8, wherein
(a) said back-up layer means comprises a thermo-setting resin material reinforced by glass fibers.

10. A lightweight armor plate for protecting an area against high energy particles, such as projectiles, by resisting the penetration thereof, said armor plate comprising
(a) a plurality of ceramic plate members of a selected predetermined size and shape having front and rear faces, said ceramic plate members being arranged in at least one layer and in closely spaced relationship with respect to each other,
(b) each of said ceramic plate members being made of a material having a hardness value of at least 400 Knoop.
(c) a shatter-resistant plastic material bonding said plurality of ceramic plate members together so as to rigidly hold said ceramic plate members in place,
(d) said shatter-resistant plastic material comprising a thermo-setting resin reinforced by glass fibers,
(e) anti-spalling front and rear fabric webs respectively secured to the front and rear faces of said plurality of ceramic plate members in covering relation thereto,
(f) an elastomeric liner disposed across the rear fabric web covering the rear faces of said plurality of ceramic plate members and secured to said rear fabric web,
(g) a metallic back-up plate secured to said elastomeric liner in covering relation thereto,
(h) said plurality of ceramic plate members being individually shatterable in response to the impact of a high energy particle thereagainst to cause the high energy particle to be broken into fragments for dissipating the force of the high energy particle while tending to divert the path taken by the fragments of the high energy particle,
(i) said ceramic plate members, said shatter-resistant plastic material, said anti-spalling front and rear webs, said elastomeric liner, and said metallic back-up plate cooperating to define a composite plate-like structure capable of containing the fragments of the high energy particle and fragments from said ceramic plate members therewithin, wherein said anti-spalling portions prevent the shattered portions of an individual ceramic tile struck by a high energy particle from flying outwardly away from the composite plate-like structure,
(j) said front and rear faces of said ceramic plate members extending generally parallel to the surfaces of the composite plate-like structure so as to dispose said one layer of said ceramic plate members in generally parallel relationship to the surfaces of the composite plate-like structure.

11. A lightweight armor plate for protecting an area against high energy particles, such as projectiles, by resisting the penetration thereof, said armor plate comprising
(a) a body of non-metallic shatter-resistant material,
(b) a plurality of ceramic tiles of a selected predetermined size and shape having substantially planar front and rear faces embedded in said non-metallic body so as to be rigidly held in place thereby, said plurality of ceramic tiles being arranged in side-by-side relationship to each other so as to define a layer of fragmentation-inducing and energy-dissipating elements,
(c) said non-metallic body including front and rear anti-spalling portions respectively covering the front and rear faces of said plurality of ceramic tiles comprising said layer of fragmentation-inducing and energy-dissipating elements,
(d) a metallic back-up plate secured to the rear portion of said non-metallic body in covering relation thereto,
(e) said plurality of ceramic tiles included in said layer of fragmentation-inducing and energy-dissipating elements being individually shatterable in response to the impact of a high energy particle thereagainst to cause the high energy particle to be broken into fragments for dissipating the force of the high energy particle while tending to divert the path taken by the fragments of the high energy particle,
(f) said non-metallic body, said plurality of ceramic tiles included in said layer of fragmentation-inducing and energy-dissipating elements, said front and rear anti-spalling portions, and said metallic back-up plate cooperating to define a composite plate-like structure capable of containing the fragments of the high energy particle and fragments from said ceramic tiles therewithin, wherein said anti-spalling portions prevent the shattered portions of an individual ceramic tile struck by a high energy particle from flying outwardly away from the composite plate-like structure,